Computerized Support for Idea Generation during Knowledge Creating Process[1]

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Abstract

Knowledge is regarded as the most important capital for organizations in the 21st century. And knowledge creation is as one of most effective methods to enhance industrial competitiveness especially along the global trend and increasing complexities in the socioeconomic development. In this paper, we combine an organizational knowledge creating model proposed by a Japanese social scientist I. Nonaka and framework of Hall for Workshop of Meta-synthetic Engineering proposed by Chinese system scientist Qian Xuesen (Tsien HsueShen) to explore how to effectively facilitate knowledge creating process using computerized supports, especially during group working context, where group discussion and debates are usual activities during idea/alternative generation and evaluations. We focus on one kind of group activities, group thinking, especially group brainstorming for idea generation, which is very basic and also convenient way to collect opinion and acquire knowledge for new alternatives or solutions towards difficult decision problems. A computerized support tool for idea generation has been developed and a simple example is demonstrated.

Keywords: Idea generation, knowledge creation, meta-synthesis, ba

1. Introduction

It is regarded that we have already been entered into the Information Age or even Knowledge Age. There are many sayings like, "the future belongs to those organizations that systematically and collectively leverage their knowledge assets", etc. Professor Robert Kaplan from Harvard University said "Managing knowledge capital will be critical for organizations to create a sustainable competitive advantage." (November 5, 2002). Intensive research is undertaken on knowledge, which seems as one of the most effective methods to enhance industrial competitiveness especially along the global trend and increasing complexities in the socioeconomic development. Among those research, knowledge management is a hot area which appeals to a lot of people, while some even disagree that term. They hold strong conviction that knowledge cannot be managed, but only be enabled (Krogh, Ichijo & Nonaka, 2000). Their perspective is based on Polanyi's (1966) distinction between tacit knowledge and explicit knowledge. Tacit knowledge is personal, context-specific, hard to formalize and communicate and therefore very difficult to be managed, but could be enabled. Explicit or "codified" knowledge refers to knowledge that is transmittable in formal, systematic language, and therefore can be managed. Then the more important is knowledge creation, and to enable knowledge creating. In this paper, we first discuss conceptual models about knowledge creation. A famous model proposed by a Japanese social scientist Ikujiro Nonaka is adopted together with a western model. Both emphasize the context, which is referred as "Ba" or platform for knowledge creation. Then meta-synthesis system approach (MSA) which is oriented to tackle with complex system problems proposed by Chinese system scientist Qian Xuesen (Tsien HsueShen) who later forwarded a framework of Hall for Workshop of Meta-synthetic Engineering (HWMSE) to explore how MSA work in practical problems. We try to combine Nonaka's knowledge creating model with HWMSE and explore how to effectively facilitate knowledge creating process using computerized supports, especially during group working context, where group discussion and debates are usual activities during idea/alternative generation and evaluations. We mainly focus on one kind of group activities, group thinking, especially group brainstorming for idea generation, which is very basic and also convenient way for opinion collection and knowledge acquisition for new alternatives or solutions towards difficult decision problems. A computerized support tool for idea

[1] Supported by Natural Sciences Foundation of Science (Grant No. 79990580 & 70221001).

generation has been developed together with a simple example, which serves as a demonstration of MSA application. Firstly we discuss concept models about knowledge creation.

2. Conceptual Models about Knowledge Creation

Even Polanyi (1966) gave a distinction between tacit knowledge and explicit knowledge, little studies had been seen to expose how knowledge transfers or converses between two types until a Japanese professor Ikujiro Nonaka proposed organizational knowledge creating model. Nonaka and Takeuchi (1995) regarded the organizational knowledge creation as a continuous, social process, which is a never-ending spiral of conversion between tacit and explicit knowledge through 4 kinds of conversion modes, *S*ocialization, *E*xternalisation, *C*ombination and *I*nternalization, which are referred as SECI model as shown in Figure 1.

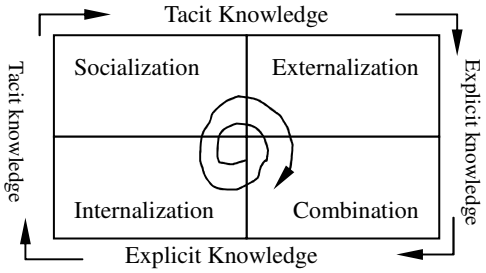


Figure 1. SECI Model about Knowledge Conversion

In Nonaka's theory, knowledge conversion or interaction is the key concept. How to enable or facilitate the interaction? In spite of those proposed conditions or enablers, Nonaka emphasized a Ba during enabling process. "Ba", a Japanese word, is defined as a platform where knowledge is created, shared, and exploited. Ba can be physical, virtual, mental or any combination of them. The knowledge-creating process is also the process of creating ba (Nonaka, Konno & Toyama 2001). Four types of Ba are related with each mode in SECI model respectively, originating ba for socialization especially at face-to-face situation, dialogue ba for externalization mostly happened between peer-to-peer, systematizing ba for combination during collaboration and exercising ba for internalization during practice. Then how to develop a right ba for exploiting and creating knowledge effectively and efficiently is a major concern in organizations. Besides, the articulation of tacit mental models within a kind of mobilization process is also regarded as a key factor in developing a good Ba for creating new knowledge.

SECI model presents a socio-cognitive perspective toward knowledge creation/production, there are also other perspectives. Gibbons *et al.* (1994) define two distinct modes of knowledge production: Mode 1 and Mode 2. Mode 1 is institutionalised knowledge and knowledge production in Mode 1 (traditional mode of knowledge production) takes place in a disciplinary context. There is a clear distinction between theory and its application in this mode of knowledge production, such as 'scientific' knowledge produced at the universities. Mode 2 knowledge is created in practice, and is increasingly produced in the application context, which shares similar meaning as Ba in SECI model.

Actually, a new discipline, knowledge science is emerging. In the first book on knowledge science, Sugiyama, Nagata & Shimojima (2002) applied widely accepted Nonaka's model as the dynamic of knowing. Beside those models on knowledge creation or production, a Chinese system scientist Qian, Xuesen also proposed a way about knowledge creation, which is meta-synthesis approach from qualitative understanding to quantitative validation.

3. Knowledge Creation based on Meta-synthetic Approach

Proposed by a Chinese system scientist Qian Xuesen (Tsien HsueShen), MSA is one of the system methodologies to tackle with open complex giant system (OCGS) problems from the view of systems in the early 1990s (Qian, Yu & Dai 1990; Qian, 2001). Here, we regarded OCGS problems are ill-structured or wicked problems. The essential idea of MSA can be simplified as "confident hypothesizing, rigorous validating", i.e. quantitative knowledge arises from qualitative understanding, which reflects the process of knowing and doing in epistemology. The approach expects "to unite organically the expert group, data, all sorts of information, and the computer technology, and to unite scientific theory of various disciplines and human experience and knowledge", for both proposing hypothesis and quantitative validating. Later it is evolved into Hall of Workshop for Meta-Synthetic Engineering (HWMSE) which emphasizes to make full use of breaking advances in information technologies (Wang, *et al.*1996). HWMSE is expected to expose the essence of meta-synthesis approach in pursuit of new ideas and knowledge and even

wisdom, then it is regarded as a system for information processing, knowledge production and wisdom integration (Yu and Zhou, 2002). It emphasizes the active roles of human beings during human-machine collaboration, which is beyond traditional decision support systems (DSS) where machine plays active roles during human-machine interaction.

The ideas of MSA and HWMSE had been propsed for more than 10 years, and continuous endeavors have been taken to put those ideas into practice. However, little influential or convincible work about HWMSE had been reached. With the tremendous development in networking and distributed computing technologies, past difficulties in implementation are disappearing together with further understandings of HWMSE and fruitful results are achieving in similar or relevant research fields in recent years in China. Gu and Tang (2002) synthesized some of those developments together with some parallel research work abroad and found there exits a trend toward meta-synthetic engineering. A major project supported by National Natural Science Foundation of China (NSFC) was approved in 1999 to exposes some strength of HWMSE support for complex problem solving, especially on macro economy decision making. In this project, one of our endeavors is to show how to facilitate proposing confident hypothesis toward complex problems. Such kind of work is regarded as qualitative meta-synthesis research and HWMSE is a test bed of meta-synthetic support for ill-structured problem solving, where resolutions about wicked issues are captured with a series of structured approximation by meta-synthesis approach (Yu and Tu, 2001). For unknown or new issues, new knowledge is often needed for a practical solution, and qualitative meta-synthesis aims to produces assumptions or hypotheses about the complex problems, i.e. to expose some qualitative relations or structures of the wicked problems. Creative solutions may refer to wisdom. And HWMSE is expected to enable knowledge creation and wisdom emergence. Then HWMSE could be treated as a ba for knowledge creating.

A variety of computerized tools, such as group support systems (GSS), creativity support system, or any idea generation tools, have been explored to support qualitative meta-synthesis. Those kind of work is based on divergent thinking, which is regarded as the origin of knowledge creation. On the other hand, “confident validation” is usually regarded as a convergent process, such as decision making process.

Next we focus on computerized support for group divergent thinking and idea generation for “confident hypothesizing”, the first step of MSA to complex problem solving. After brief discussion of idea generation and its practice method, brainstorming, an augmented support tool for idea generation is introduced together with a simple example.

4. Idea Generation for Creative Solutions for Problem Solving

In order to develop hypothesis (scenarios or multiple perspectives) towards unknown issues during problem solving or decision making process, creative ideas are always desired especially for different perspectives development. One of primary aims of divergent thinking is for idea generation. Idea generation usually starts with a topic, which is the anchor for creative thinking and insights of the topic are expected to be acquired or for futher investigation from a variety of expanding aspects. Developed by Osborn in the 1950s, brainstorming is a widely used method for idea generation. Brainstorming typically occurs in a spontaneous, free-flowing manner, such that the ideas are generated in a random, unorganized fashion. Divergent thinking may be regarded as a knowledge creating process while convergent thinking as a knowledge synthesis process.

Idea generation can be applied to both individuals and groups. Due to the interaction within the groups, there are different effects between individual brainstorming and group brainstorming; while the latter has been widely studied since group work is very basic in organizations. Group brainstorming serves as very basic and convenient ways of opinion collection and knowledge acquisition in organizations. Paulus & Yang (2000) studied stimulation effects during interactive group work and found additional associations or ideas may be observed during idea sharing and generation in groups while knowledge may be emerged from cognitive psychology perspective. Those studies about group work provide one sort of cognitive basis about the development of ba for group knowledge creation.

Both cognitive psychology perspective toward group process and socio-cognitive perspective toward knowledge creation provide basic framework for enhancing group creativity. Moreover, cognitive perspective has proved that the involvement of computers facilitates knowledge exchange and additional associations during group process, which was applied by Niwa (1986) into developing man-machine

cooperative system instead of a traditional knowledge-based system (expert system) for project risk management, while his focus is still on explicit knowledge based a structured paradigm and for individual use. Next we address our work to demonstrate man-machine collaborative support for idea generation.

5. Brainstorming Argumentation for Idea Generation

We mainly focus on computerized support for group interaction for idea generation, i.e. to develop computerized aid for the development of originating ba. Nowadays, a variety of web applications provide versatile platforms for information exchange via the Internet. Most web-enabled forums can be regarded as simple electronic brainstorming sessions. However, most statements are only posted as simple texts. Some text mining techniques are applied to provide relevant information (similar web pages) to stimulate participants into further exploration. Visualization is another effective way to expose hidden relations or structures of current topics in the brainstorming session and enhance participants' association abilities for further thinking. Much research had been done on visualization to augment support for information and knowledge sharing (Pracht, 1986; Mase, Sumi & Nishimoto, 1998; Hirata, Kubota & Nishida 2000). There are also other visualized tools to facilitate argumentation and decision making, like tools based on cognitive mapping (Eden & Ackermann, 2001) or dialogue mapping (Conklin, et al.2001) or both (Pidd, et al, 2003). Here we mainly concern idea sharing for hypothesis generation for qualitative meta-synthesis.

Our developed computerized environment group argumentation environment (GAE) is an online conversation system based on browser/server framework as shown in Figure 2.

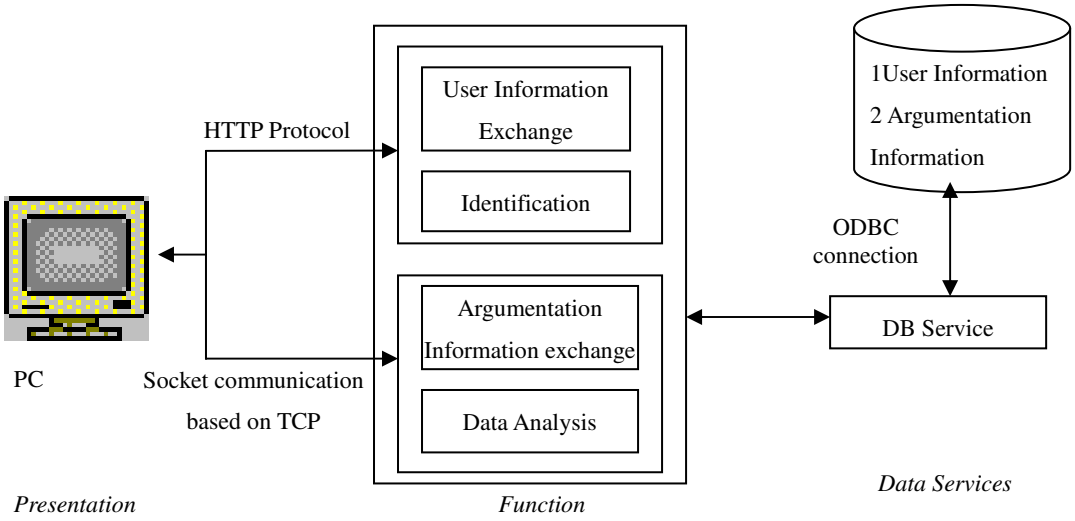


Figure 2 Functional Framework of Group Argumentation Environment

Besides general operations which are fulfilled by most B/S framework, one of the salient features of GAE is on data analysis module, which deals with qualitative data (such as utterance). GAE support electronic brainstorming while absorbing some ideas from Mase, Sumi & Nishimoto (1998). Registered participants enter into brainstorming argumentation room (BAR) by logging into the GAE under some selected or newly created discussion topic. Figure 3 shows a client window of GAE (as the presentation part in Figure 2) whose layout is consisted of event record area, interactive area and viewing area. The event record area locates in the upper left side of the window which record all events happened as the participants log on, such as all current participants and their log on/off information, utterances of all participants, etc. The lower left side is a place where user submits his or her utterances and keywords. Viewing areas include a shared visual space and three viewer buttons. Relevant information is displayed as a specific viewer button is clicked. Three viewers are:

Common viewer, a discussion space as a joint thought space for the participants. Via the 2-dimensional space, the idea association process to stimulate participants' thinking, idea generation, tacit knowledge surfacing and even wisdom emergence is exhibited based on the utterances and keywords from participants. The global structure and relationships between participants and their utterances are

shared by all participants in the session. It helps the user to acquire a general impression about each participant's contributions toward the discussing topic, and understand the relationships of each thinking structure about the topic between participants.

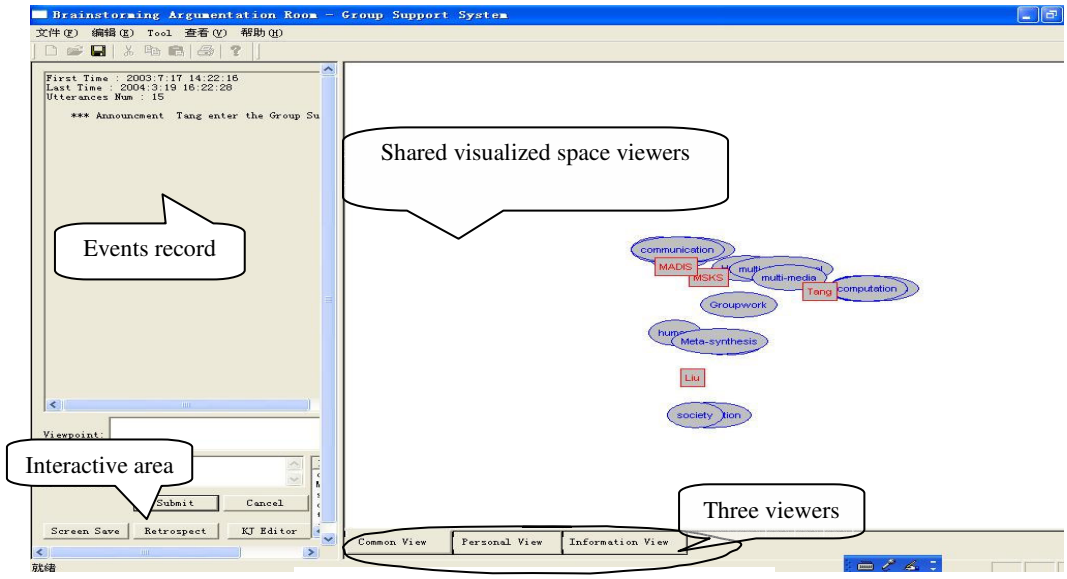


Figure 3. Client Window of BAR system

Personal viewer, a personalized space recording individual thinking process during discussion. It provides a personalized idea-gathering space where the relationships between utterances and keywords are visualized. Individual creativity may be stimulated through personalized work via this personalized space. It helps the user to understand how one piece of information (utterance) affects the group thinking process and understand the relationships between each participant's mental process.

Information viewer, also as search viewer, which provides access to outside information, such as those Internet searching engines (such as Google), by which participants acquire relevant Web links about concerned topics. Other processing tools for text mining and information filter may also be included for efficient information support.

As the server accepts the utterances and keywords submitted by users, new idea associations are generated and the result is displayed in the shared space. The association process employs dual-scaling method for qualitative processing of statements and keywords. Dual scaling is a multi-variant statistical method that owns similar characteristics with correspondence analysis and exploratory factor analysis (Nishisato, 1980).

Table 1 Utterance sets and keyword sets

Y \ X	keyword$_1$ x_1	keyword$_2$ x_2	… …	keyword$_m$ x_m	
utterance$_1$ y_1	a_{11}	a_{12}	…	a_{1m}	$y_1=\sum_{i=1}^{m} a_{1i}x_i$
utterance$_2$ y_2	a_{21}	a_{22}	…	a_{2m}	$y_2=\sum_{i=1}^{m} a_{2i}x_i$
⋮	⋮	⋮	⋱	⋮	⋮
utterance$_n$ y_n	a_{n1}	a_{n2}	…	a_{nm}	$y_n=\sum_{i=1}^{m} a_{ni}x_i$

With the given n utterance-objects and m keyword-objects which construct a $n\times m$ matrix, dual scaling provides the principal components for given relations between keywords and utterances (Table 1, where a_{ij}=0, when keyword j is not mentioned in utterance i otherwise, a_{ij}=1). Thus, the relations between concepts (utterances-objects) and their elements (keywords) are represented by spatially arranging the concepts and the elements. Adding utterances leads to changing of the matrix, therefore the spatial arrangement is also changing according to timely processing of the latest frequency matrix. The math underlying dual scaling is based on calculations of eigenvectors and eigenvalues of a frequency matrix. As a result, a pair of utterances with more common

keywords may locate closer in the 2-dimention space. In the common viewer, utterance object is the participants; participants who share more keywords may be within a cluster. Here share keywords may mean participants hold similar concerns toward those keywords.

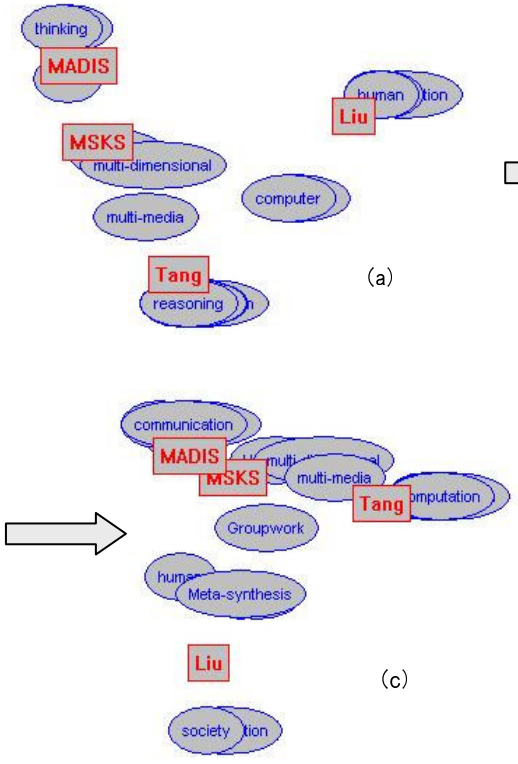
6. An Example

An experiment is taken with GAE in July of 2003. The discussion topic is about group support systems. Four persons whose registered IDs are Tang, Liu, MSKS and MADIS respectively participated the discussion. Firstly, each participant expressed their opinions toward the concerned topic. Table 2 lists their first utterances and relevant key words.

Table 2. Initial Utterance by each Participant

User ID	*Utterance*	*Keywords*
Tang	connectionism	Connectionism, association
MADIS	visualizing multi-dimensional spaces	multi-dimensional, visual, hypertext
MSKS	multi-media	multi-media, hypertext, visual
Liu	Computer Support Collaborative Work	collaboration, groupwork, computer

The opinions from both MADIS and MSKS, especially on “hypertext” expand Tang’s views. As the discussion went on, Tang also took interested in Liu’s utterance “society of mind” and added “computation in mind”. Other members also input their viewpoints by interaction. The whole discussion was under such an interactive and collaborative ambience. The server of GAE processed participants’ utterances in a fixed interval and sent back the results to the client which displayed the results into a



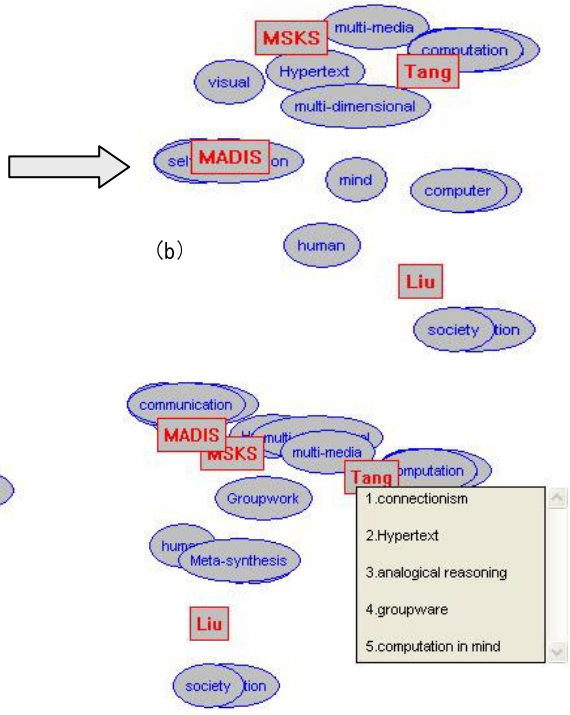


Figure 4 The snapshots of the common viewer of BAR system

Figure 5. List all utterances of one participant

2-dimension space. Figure 4(a) and (b) are two snapshots from the common view during the whole discussion process; Figure 4(c) is the final map about all 15 utterances. The rectangular icons are name of participants as the utterance-objects; the oval icons are keyword-objects, contributed by participant for

each utterance. From those snapshots, it can be seen that both MADIS and MSKS shared similar interests since the start of discussion. Even the process is dynamically evolving and both participants' thinking is changing, both are still closer to each other than to other participants, which may indicate their similar concerns on GSS. When moving mouse to the rectangular, all utterances of the focused participant will be displayed (Figure 5). Due to space limitation, introduction of the discussion evolving process in personal viewer is omitted.

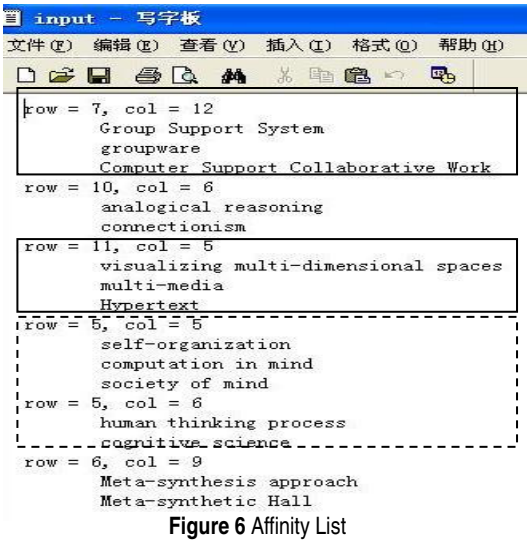


Figure 6 Affinity List

Based on the last spatial space in the personal viewer, GAE divides the whole utterance set into 6 cells according to their space relationship and generate an affinity list as shown in Figure 6. BAR It could be seen the utterances in one cell are related to each other. For example, all 3 utterances within Cell [row 7, col=12] are about GSS or similar tool systems, then that cell could be titled as group support system. On the other hand, all 3 utterances within Cell [row=11, col=5] exhibit concerns on man-machine interaction. Automatic affinity list could be regarded as a rough classification about participants' opinions during the brainstorming session. Further processing could be taken to acquire a more reasonable classification. For example, those utterances within the adjacent Cell [row=5, col=5] and Cell [row=5, col=6] reflect concerns on human recognition and decision making process, which are basis about GSS development, and could be grouped into one cluster. Such kind of further processing by human experts based on automatic processing also exhibits the ideas that man-machine interaction while man plays principal roles in MSA.

Visualized analysis transforms qualitative knowledge into a 2-dimenstional map, which helps the participants to understand others' opinions easier, find common interest, stimulate further thinking, acquire intuition and insight, facilitate knowledge sharing and new ideas generation. Computerized group argumentation environment may avoid disadvantages during face-to-face discussions and help participants to express individual ideas more freely, which are improvement of traditional brainstorming process.

The evolving clusters of utterance icons and surrounding keyword icons may stimulate knowledge association during brainstorming session. The group-writing paradigm which BAR applies is one of conditions which Paulus & Yang (2000) recommend; while dynamic visualized structures of the concerned topic may reinforce the stimulation during group interactive process, highlight both hot or cold foci and facilitate further thinking. The evolving diagram may also help to find some hidden structures toward those complex problems for decision makers. Such a work is oriented to maintain an interactive ba and facilitate for idea emergence during group divergent thinking process

7. Conclusions and Remarks

In this paper, we combine knowledge creation models with Hall for workshop on meta-synthetic engineering for creative idea generation during problem solving process. A visualized conversation support environment is presented to demonstrate the strength of HWMSE in the development of right Ba for knowledge exchanging and idea generation during group process. The work has started in 2001 and been improving continuously (Tang & Liu 2002, Liu & Tang 2003).

Currently, our major concern is on divergent thinking process, for confident hypothesis formulation in qualitative meta-synthesis. Next major improvements may include personalized processing in personalized viewer, improvements in human-machine interaction (automatic extract keywords from utterances), further utilization of group utterances set and enhancing functions in the information viewer (e.g. text mining and web mining). Besides, more interactive functions will be considered to enhance the capacity of personal viewer in GAE.

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